Spring 2004
Industry Study

Final Report
Space Industry

<u>**The Industrial College of the Armed Forces**</u>
National Defense University
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SPACE

ABSTRACT

Space captures the hearts and minds of the world because it represents the future of humanity. We are by nature explorers; we seek to understand the unknown and space is a vast unknown. Like all previous pursuits into the unknown by mankind, there are huge risks and challenges associated with the exploration of space. These challenges include the complex technologies necessary to safely travel the hazardous environment and great distances of space, as well as the public will and commitment of resources required to sustain the long-term drive. Space is an industry full of intrigue worth billions. Our industry study report addresses the current condition and challenges of the global space industry and provides recommendations that may ease our journey into the frontier.

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Ball Aerospace & Technologies Corporation, Boulder, CO
Boeing Delta IV Florida Launch Facilities, Patrick AFB, FL
Boeing Satellite Systems, El Segundo, CA
Boeing Expendable Launch Services, Decatur, AL
California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA
DigitalGlobe, Longmont, CO
Missile Defense Agency, Ground Based Midcourse Defense, Redstone Arsenal, AL
John F. Kennedy Space Center, Kennedy Space Center, FL
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Lockheed Martin Space Systems, Cocoa Beach, CA
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INTRODUCTION

In today's globally connected environment, space-based assets exert ubiquitous influence across virtually all sectors of modern and developing economies. The seamless integration of space is oftentimes so effective and transparent that the significance of its role is underestimated, clouding an appreciation for its critical role in employing the instruments of national power and its increasingly prominent role in globalization.

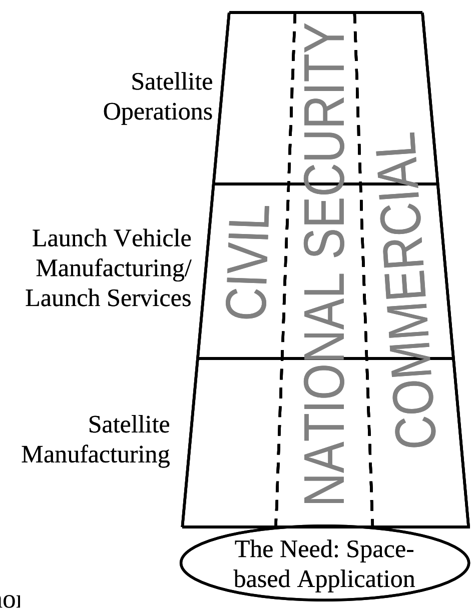
Space assets enhance employment of all the instruments of national power: diplomatic, information, military and economic. Much of the U.S. prominence in the world depends on the intelligence and communications assets based in space.

In his award-winning book, Thomas Friedman describes globalization as a new international system whose overarching principle is the "integration" of markets, nation states, and technologies that enable global access to a degree never before possible.[1] The degree of connectedness to an increasingly global marketplace directly affects the strength of a nation's economy; technology is the key to connectedness. The ability to use space to exploit the full potential of technology to enhance economic activity makes space vital to intra- and international commerce.

This report offers an executive summary of the industry; its status and prognosis, an analysis of a few of its major challenges, and presents recommendations on several important issues. Four essays on major issues are included: Space Technology, Export Controls, Commercial Remote Sensing, and Space Weaponization.

THE INDUSTRY DEFINED

Three generally accepted sectors of space activity constitute the space industry: (a) civil space, (b) national security space, and (c) commercial space. These three sectors are not mutually exclusive; they are inextricably linked by the inherent dual-use aspect of most space industry infrastructure and systems. Each sector participates in three space industry "markets": (1) satellite manufacturing, (2) launch vehicle manufacturing and launch services, and (3) satellite operations. Events and economic activity in one



Space Industry Model

[1] Friedman, Thomas. The Lexus and the Olive Tree, New York: Ancho

element of the space industry directly impacts other industry markets and sectors.

Civil Sector. The civil sector serves the public good with research and development for manned and unmanned scientific missions—all for primarily non-military applications. This sector also fosters multinational cooperation in space (e.g. the International Space Station). The National Aeronautics and Space Administration (NASA) is the lead agency for U.S. civil space activities. By far, the largest and most significant foreign peer (competitor and partner) is the European Space Agency (ESA)[2]. ESA is comprised of members from 17 European countries.[3] The three largest components of ESA—the French,[4] Italian,[5] and German[6] Space Agencies—contribute nearly 70% of ESA's total budget. Other non-ESA foreign civil space agencies are much smaller and are almost exclusively national programs. They include the Canadian Space Agency, Japan's National Space Development Agency, Russia's Rosviakosmos (RKA), and India's Space Research Organization.[7]

Hallmarks of the manned space program are the U.S. Space Transportation System (STS) or Space Shuttle, the Russian *Soyuz*, and the International Space Station (ISS). With its recently successful manned space flight, the People's Republic of China[8] is rapidly emerging as a potential peer competitor in manned space operations. China's future includes plans for a space laboratory and permanent space stations.[9]

Unmanned space missions also play significant roles in technology development, communications and health, and the continued commercial viability of space. NASA, industry, and scientific universities have created a powerful and successful technology team for the U.S., [10]

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[2] See http://www.esa.int/export/esaCP/index.html.

[3] ESA's 17 Member States are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom, plus Greece and Luxembourg who became members in 2004. In addition, Canada and Hungary participate in some projects under cooperation agreements.

[4] Centre National d'Etudes Spatiales (CNES), http://www.cnes.fr/html/_.php.

[5] Agenzia Spaziale Italiana, http://www.asi.it/index.htm.

[6] Deutschen Zentrum für Luft- und Raumfahrt (DLR), http://www.dlr.de/dlr/Unternehmen.

[7] Canadian Space Agency (CSA) / Agence Spatiale Canadienne, http://www.space.gc.ca/asc/eng/default.asp; National Space Development Agency of Japan, http://www.nasda.go.jp/index_e.html; Russian Space Agency (RKA), http://www.rosaviakosmos.ru/english/erka.html; Indian Space Commission and Department of Space, http://www.isro.org/about_isro.htm.

[8] China National Space Administration (CNSA), http://www.fas.org/spp/guide/china/agency/cnsa.htm.

[9] International Space Business Council, *2004 State of the Space Industry*, Space Publications LLC (2004), p. 22.

[10] For example, the Solar Dynamics Observatory (SDO) will measure a broad spectrum of solar emissions. By analyzing the solar seismic and magnetic effects on the earth's heliosphere, SDO will give scientists the ability to predict the severity of solar events and the degree of hazard they represent to humans and machines. One significant improvement of SDO over the older generation solar observer is the sheer quantity of data it will transmit—about

representing a significant part of our nation's competitive advantage and security in space. For more information on space science and technology, see the essay included below.

National Security Sector. The national security sector includes an array of military and intelligence activities, including secure communications, navigation and timing, missile warning, and signals and imagery intelligence. The national security sector provides national leaders with asymmetric advantages in developing and implementing foreign policy, and when employing the military instrument of national power.

Our national security space sector has experienced significant reorganization in recent years. In 2001, the Undersecretary of the Air Force was given additional roles as Director of the National Reconnaissance Office (NRO) and DoD Executive Agent for Space, vested with DoD-wide authority over the national security space program. Air Force, Navy and Army Space Commands are responsible for organizing, training, and equipping military space operations forces, while the United States Strategic Command (USSTRATCOM) is the unified command responsible for execution functions during hostilities. The NRO purchases and operates intelligence-gathering satellites, and the National Security Agency (NSA) and National Geospatial-Intelligence Agency (NGA) are the primary customers for this intelligence data.

Other space-faring nations—most notably Russia and China—have military and intelligence organizations to leverage capabilities derived from space-based assets. The U.S., however, enjoys undisputed dominance in space, made possible by budgets that dwarf all other nation's military space programs, as well as the increasingly seamless integration of space-based assets with significant elements of air, land and sea forces. Although no nation has deployed a purely offensive space-based weapon system, the dual-use nature of some space-based assets makes it increasingly difficult to maintain a distinction between offensive and defensive space systems. (For discussion of weaponization in space, see the essay included below.)

Commercial Sector. More than any other people, the citizens of the U.S. rely on the commercial space sector for their way of life. Remote sensing by optical, radar and infrared provide images of various forms to benefit land use, agriculture, oceanography, and meteorology. (For a larger discussion about commercial remote sensing, see the essay included below.) Communications services are the most prominent—and most lucrative—of the commercial space applications, providing television, telephony, internet, and radio. Commercial space products and services also provide key contributions to our national defense and intelligence missions.

1,500 Gigabits of information, every day. See Irene Yachbes, "The Next Great Sun-Watching Spacecraft," http://www.space.com/businesstechnology/technology/sdo_tech_040324-1.html, Mar 2004.

During the first decades of space exploration, advances were fueled almost exclusively by government investment. As commercial space activity expanded, government and industry alike assumed the commercial sector would drive future advances in space technology and its application. These assumptions have not been borne out by the market. Although the past year saw a modest increase in commercial orders for satellites and launch vehicles,[11] companies still suffer from the overall stagnant marketplace of the past several years and lack the resources to invest aggressively in research and development programs. With revenue growth flat, investors cautious, and high costs to amortize over few contracts, companies do not have the margins to aggressively invest in research and development programs. To facilitate private sector investment, ownership, and operation of space assets, the government continues to allow commercial sector access to government-owned hardware, facilities, and data through an array of partnerships with industry and educational institutions.

Although the space industry is divided into these three sectors, they most often act interdependently. For example, sector cooperation permits larger technology advances to occur despite scarce research and development resources. A symbiotic relationship results: government and business have produced a harmony of effort that helps the industry survive in lean times such as we are now experiencing.

CURRENT CONDITION

U.S. space dominance is the fruit of decades of investment at rates several times that of any other nation. In 2002 for example, the total U.S. space investment across all sectors was approximately $35.5 billion,[12] while European investment is estimated at $4.8 billion and China's investment is estimated between $1.5-2.4 billion per year. This significant (15:2:1) difference, however, does not guarantee a commensurate advantage in space accomplishments. The following sections discuss the current market conditions and top news stories of the academic year, establishing a basis for the analysis discussions that follow.

Market Condition. Despite the tremendous resources of the space industry, much of the industry infrastructure is "graying" in physical and human terms. An incomplete vision, faulty strategy, or erroneous business plan can result in great people and resources at times competing with each other for survival projects. Instead of the industry's resources working together in a complementary manner, hardships such as the current overcapacity must be endured. If the U.S.

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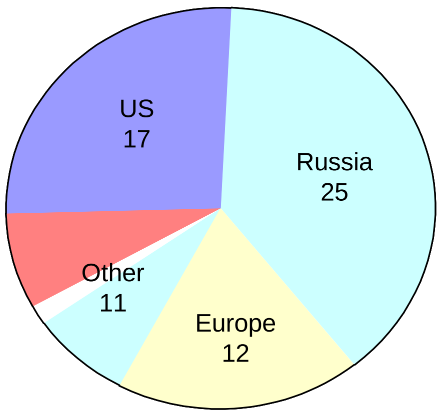
[11] International Space Business Council, *2004 State of the Space Industry*, Space Publications LLC, p. 2.
[12] Gugliotta, G. and Pianin, E. "Spaceflight Debate Pits Man vs. Machine," *The Washington Post*, 27 Feb 2003, p. A6.

is to maintain its advantaged position in the space industry, efficient and effective policies are just as critical as the amount of investment.

Market Players. Significant consolidation occurred within the space industry during the last decade. European and U.S. commercial space business plans—formulated during boom times of the late 1990s—failed with the 2001 telecom bust and general economic slump. Corporate caution and struggle to maintain the status quo is apparent, pending the expected economic resurgence and renewed confidence in government space leadership.



Global Launches (65 total) in 2003,
Source: BAH, April 2004

There are many satellite manufacturers in the world; the largest are Boeing, Alcatel, EADS Astrium, Lockheed Martin, and Loral Space and Communications. The primary U.S. launch service providers are Boeing and Lockheed Martin. Both these contractors are participating in the U.S. Air Force's Evolved Expendable Launch Vehicle (EELV) program to supplement the Space Shuttle as our primary space transport. There are several international launch providers, with the Russian Space Agency (RKA)[13], Arianespace[14], Sea Launch[15] and International Launch Services[16] dominating this market. The launch vehicle and launch services contribute about 25% of the total cost for a space project.[17]

Nature of the Market. The space industry is an oligopoly-oligopsony economic relationship due to the limited number of suppliers for space and the limited number of major buyers within the market place. The global space industry has substantial entry and exit barriers. These include government regulation, high capital investment costs, sophisticated infrastructure requirements, highly skilled labor requirements, and high insurance costs. Additional barriers include rigorous

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[13] See http://www.fas.org/spp/guide/russia/launch/index.html.

[14] Arianespace is responsible for the production, operation and marketing of the Ariane 5 launchers. See http://www.arianespace.com/site/about/about_index.html.

[15] Sea Launch is an international partnership of American, Russian, Ukrainian and Norwegian businesses that provide ocean-based launch services. Aboard a modified oil-drilling rig floating at the equator, the Sea Launch Zenit-3SL rocket can lift a heavier spacecraft mass direct to geostationary orbit or place a payload into a higher perigee. The Sea Launch web site is located at http://www.sea-launch.com/.

[16] International Launch Services (ILS), a joint venture between Lockheed Martin and Khrunichev State Research and Production Space Center (Russian), and provides satellite launch services using Atlas and Proton launch vehicles. See http://www.ilslaunch.com/whoweare/.

[17] FAA, "Selecting a Launch Vehicle", Second Quarterly Report Topic, 2001, p. QRT-4.

legal requirements, strict environmental standards, and government subsidies to current players. In addition, exit strategies must deal with environmental concerns for divesting infrastructure that often uses hazardous material and infrastructure that has limited alternative uses to recoup equipment costs. The consequences of these entry barriers are stark; they prompt several of our recommendations and warrant greater analysis below.

Market Importance. Space-based applications have become a critical element in the global information architecture. Contemporary financial and telecommunications infrastructure are critically dependent upon space-based communications and timing signals. The transportation industry and other key segments of the economy depend on satellite navigation capabilities provided by the Global Positioning System. Meteorology and remote sensing satellites are also critical to the nation's well being.

Modern military force effectiveness depends upon these same dual military-civil use capabilities as demonstrated by recent operations in Afghanistan and Iraq. Unique military capabilities such as precision guided weapons, signals intelligence, missile launch warning, and nuclear detonation warning are critical satellite enabled capabilities. U.S. military superiority is highly dependent upon its space infrastructure and capabilities.

Top News Stories Affecting the Industry. Several stories about the space industry were prominent in the news during the school year. Those that have important consequences for the future of the industry are mentioned below.

- The space industry and media were clearly focused for much of 2003 on the Columbia accident and the ensuing investigation. The space shuttle remains grounded, and its return to flight, once projected for September 2004, has shifted to May 2005.[18] The Shuttle's return to flight is critical, since it is the only vehicle that can fulfill the U.S. commitment to deliver the large modules and supporting trusses necessary for International Space Station (ISS) completion.
- On October 15, 2003, The People's Republic of China became the third country to launch and safely return a human into space. While Lt Col Yang Liwei only completed 14 orbits onboard the Shenzhou V, it was a significant accomplishment for the Chinese and demonstrated their space engineering capabilities. It bolsters Chinese ambition to become a major player in the space industry.[19]
- President Bush presented a bold new vision for NASA in January 2004. The centerpiece is to establish permanent habitation on the Moon by 2015 and for a manned mission to Mars by 2030. To accomplish this, NASA plans to develop a Crew Exploration Vehicle replacement for the Shuttle. The Shuttle will retire from service in 2010, and until then will be used primarily for ISS

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[18] Space Business.com, "2004 State of the Space Industry," February 2004, pp. 4-5.
[19] Space Business.com, "2004 State of the Space Industry," Feb 2004, pp. 4-5.

missions. An additional 5% appropriation, plus the Shuttle program's resources following its retirement, is supposed to be sufficient to fund the new vision.[20]

o Two identical Mars exploration rovers, launched in 2003, successfully arrived on Mars in January 2004. Robotic rover "Spirit" landed in a wide basin thought to have once been a lake. "Opportunity" landed near a large outcropping of gray hematite – a mineral usually formed in the presence of water. Instruments on the rovers enable study of geologic history and evaluation of their landing sites for suitability to life.[21] The success of these scientific missions generated much enthusiasm and support for NASA and its civil space activities.

o Through a joint undertaking, the European Space Agency (ESA) and the European Union (EU) approved the financing plan for the Galileo project and let a contract for the first platform.[22] Galileo will be Europe's own global navigation satellite system, providing highly accurate, guaranteed global positioning service under civilian control.[23] The U.S. Government and the EU will likely achieve consensus on signal interference issues (such as the important M-code) allowing users access to both Galileo and GPS.[24]

ANALYSIS AND RECOMMENDATIONS

The following discussion is intended to offer our view of a few "constellations" of current space industry issues. Collections of "star" issues are grouped together under four connecting ideas: Political Will, Overcapacity, Barriers to Entry, and Acquisition. Challenges, the outlook, and the role for government are addressed. Where we have a recommendation about the issue, it is made.

Political Will and Public Support for Space Activities. The United States' space program enjoys a rich legacy of an ambitious national vision, a strong national will to achieve space dominance, large budgets, and phenomenal physical and intellectual risk-taking. As President

[20] "The Vision for Space Exploration," National Aeronautics and Space Administration. Available at http://www.nasa.gov/pdf/55584main_vision_space_exploration-hi-res.pdf., p. 19.

[21] "NASA Facts: Mars Exploration Rover," National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, CA. Available at http://www.jpl.nasa.gov/news/fact_sheets/mars03rovers.pdf.

[22] The current phase of development and validation covers the detailed definition and subsequent manufacture of 4-6 prototype satellites, the creation of a minimal terrestrial infrastructure, and ITU-compliant user receivers. The first prototype satellite is planned to be on orbit by late 2005. The full 30-satellite configuration is expected to cost approximately $4.2B and be completed by 2008. As an expert on space commerce noted during a briefing to our seminar, this seems like an aggressive timeline with inadequate funding. He predicted that Galileo would either meet the timeline with reduced geographic coverage of Europe only or massive funding restructures will be required. Thus far, ESA and EU are sharing costs equally. User fees are planned to cover operating costs.

[23] See http://europa.eu.int/comm/dgs/energy_transport/galileo/programme/phases_en.htm.

[24] "US And EU Poised To Agree On Satellite Navigation Networks," *London Financial Times*, Feb 3, 2004.

John F. Kennedy said when explaining his 1961 vision, “We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard.”[25] Despite the high costs and risks, the rewards of the Apollo program were rich and plentiful. Among the results of the nation’s quest to land on the moon were national prestige, myriad “spin-off” technologies, and a strong space industry that could keep the U.S. on the leading edge of technological development throughout the Cold War. In short, from President Kennedy’s vision of one identifiable concept—to land people on the moon—the nation has enjoyed many lasting benefits.

New Vision. President George W. Bush’s vision for a renewed commitment to space exploration potentially sets the stage for more decades of new discoveries, new technologies, new industries, and new international relationships.[26] In contrast with the response to the Kennedy vision, however, there is no groundswell of public enthusiasm for the new Mars initiative. Recent political opposition to the program has focused on competing national priorities; in a tight fiscal environment even the most worthy ambitions can be set aside to accommodate more pressing needs. The question becomes whether the expected outcomes of space exploration significantly justify setting aside or curtailing other national priorities. At the core of the issue, then, is whether the government can generate and sustain the political will necessary to dedicate the resources necessary to return to the moon and to continue the journey to Mars and beyond.

Early actions in Congress indicate support for the President’s initiative.[27] This is good news for the proponents of the plan; however, this is only the beginning of what is expected will be a twenty- to thirty-year endeavor. Even if the initial allure of renewed exploration results in early funding, the issue is sustainment over the next few decades.[28] Achieving the vision is contingent on keeping the political will to fund it for the long term. That will be the challenge for the next two or three decades.

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[25] “White House Tapes Shed Light on JFK Space Race Legend,” http://www.space.com/news/kennedy_apes_010822.html.

[27] “President Bush Announces New Vision for Space Exploration Program,” www.whitehouse.gov/news/releases/2004/01/20040114-3.html.

[28] Sietzen, Frank, “Analysis: Congress Warms to New Space Plan,” UPI, in http://www.upi.com/print.cfm?StoryID=20040330-111655-8797r, Apr 6, 2004. “Now, after weeks of unrelenting skepticism by members of Congress, a bipartisan coalition may be coming together to approve a down payment on the moon-Mars proposal. Senior administration sources told United Press International that support in the House of Representative (sic) has improved chances to give NASA the full $16.244 billion it has requested for fiscal year 2005 -- an $866 million boost over last year's funding.”

[28] Berger, Brian, http://www.space.com/news/moon-mars_public_040211.html. Edward Aldridge stated recently, "I think the biggest stumbling block is ensuring sustainability. The continuation of support for such a program has to survive multiple presidencies, multiple Congresses, [and] multiple generations."

The government's role is to generate and maintain the political will to realize the President's initiative. This responsibility falls predominantly on NASA. NASA should clearly define the goals, objectives and timeline associated with the extended program. Additionally, NASA must establish and sustain a public relations campaign to Congress and to the American people in order to set the stage now for a sustained program that truly has the chance to bear fruit as envisioned.

International Partnership. Perhaps more importantly, NASA should also establish a healthy working relationship with potential global partners in the Mars endeavor. Because of the cost and the risk, the ability to accomplish the Mars mission will likely depend on cooperation with the European Space Agency (ESA), Russian Space Agency (RKA), and other nations. This will require a great deal of diplomatic negotiation and political compromise among the key players. But establishing healthy international partnerships in the short run will greatly assist in maintaining U.S. national will over the next few decades. The theme of "international partnership" (instead of "unilateral U.S.") will be among the most powerful labels that this and succeeding administrations can employ to gain congressional and public support for expanded space exploration.

> RECOMMENDATION: **Work with ESA & RKA toward a collaborative Mars exploration vision.** This would ensure global unity of effort in this pursuit. We also believe that NASA needs to begin work immediately with ESA and RKA to develop a multilateral approach to manned space exploration.

Coherent National Space Policies. In June 2002, President Bush issued NSPD-15[29] to initiate a rolling review process for National Space Policies. The process was to report new policies on (1) commercial remote sensing and foreign access to remote sensing space capabilities, and (2) space transportation policy. A third report was to recommend revision, consolidation, or elimination of other "existing national policy statements related to space activities." The review process was interrupted by the Space Shuttle Columbia accident and the subsequent reevaluation of the Shuttle's role in our space transportation future.

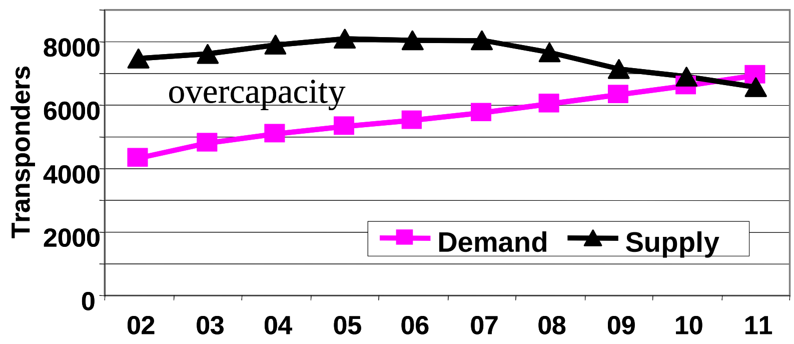
> RECOMMENDATION: **Complete the review and publication of our national space policy.** The executive Branch must finish the rolling review of policies for commercial remote sensing, space transportation, global navigation and timing,

[29] See http://www.fas.org/irp/offdocs/nspd/nspd-15.htm.

and satellite export controls, and then publish a comprehensive national space policy.

Overcapacity in Satellite Services and Launch Vehicle Manufacturing. "The overarching, primary, preeminent, paramount commercial space industry issue is OVERCAPACITY," says Philip McAlister, the Director of the space industry research firm Futron.[30] The space industry is awash in overcapacity, especially in the satellite services and launch vehicle markets.

Satellite Services. Growth rate for satellite bandwidth demand was 31% for the eight years prior to 2003, but bandwidth supply grew 54%. The satellite transponder market has consequently accumulated an excess supply of 29%.[31] Demand for satellite bandwidth is likely to accelerate to 4.3% per year, compounding to 40% cumulative growth for the eight years through 2012. Current forecasts indicate that the commercial satellite communications overcapacity gap will not close until 2011.[32]



GEO Satcom Capacity Supply vs. Demand, Source: Futron, Feb 2003

This healthy growth rate for bandwidth, however, no longer correlates to a corresponding growth rate for new satellite manufacturing. Communications satellites are now built with more transponders and a longer service life, yielding a satellite that is 9 times more capable than one delivered in 1990. The demand for satellites—and launch vehicles to put them in orbit—is therefore suppressed.

Launch Services. In the five years leading up to 2003, the average number of launches per year decreased from 82 to 62. Of 350 launches, Russia had the greatest share at 38%, the U.S. next at 35%, Europe had 13%, China at 6% was followed by Japan, India, Israel, Brazil and multinational efforts at below 3% each. In 2003, there were 63 space launches and two launch failures. With a recent average and trend toward approximately 60 launches per year, the international launch vehicle/service market is operating at about one quarter of its capacity.[33] As

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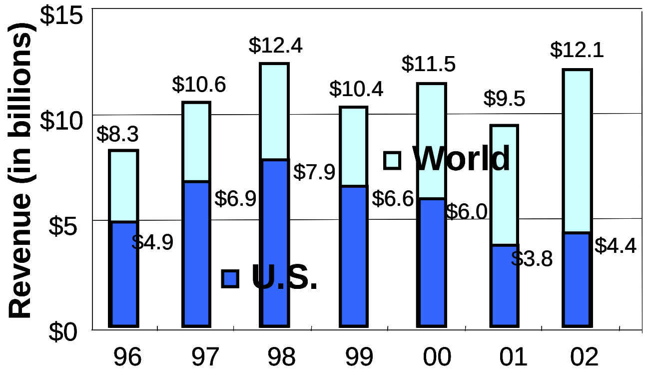
[30] McAlister, Philip,"The State of the Space Industry," Futron briefing, Jan 8, 2004.
[31] Euroconsult briefing, May 2004, Paris France.
[32] McAlister, Philip, "The State of the Space Industry," Futron briefing, Jan 8, 2004, pp. 5,6,10,12,13.
[33] McAlister, Philip, "The State of the Space Industry", Futron briefing, Jan 8, 2004.

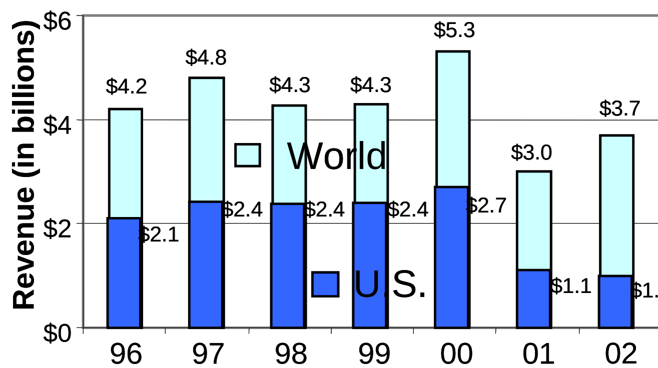
commercial launch demand decreased by 29%, the revenues they generated decreased by 37%.[34] This sharper decrease in launch revenues is a consequence of the overcapacity, and betrays the faulty commercial launch market predictions that induced launch vehicle manufacturing expansion in the late 1990s.



Satellite Manufacturing Revenues, Source: SIA, Feb 2004

The downturn in commercial satellite communications and launch demand has been moderated by the government sector. The U.S. Government has made major purchases of transponder capacity for military operations in Afghanistan and Iraq. Market predictors[35] expect this surge demand to be "retained in the military operational memory' and drive new demand for communications satellites. The U.S. Government has further mitigated the industry's lean times by building and launching new or replacement military and intelligence satellites.

Assured Access. In a further move to compensate the industry during the launch market depression, EELV contractors Boeing and Lockheed Martin will to be paid 50% more than initially contracted for government launches. The additional funding is required to cover fixed costs that companies must spread across fewer anticipated commercial launches.[36] According to Richard McKinney, the Air Force's Deputy Director of Space Acquisition, "payments will increase to as much as $135 million per launch from $91 million. Because the services want to ensure the companies stay in the military program. We are going to pay more; the



Launch Industry Revenues, Source: SIA, Feb 2004

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[34] FAA, "Commercial Space Transportation: 2003 Year In Review", Jan 2004, pp. 1,6,7,8,13,14.
[35] Satellite Industry Association briefing, Feb 2004.
[36] Capaccio, Tony, "Payment Rates Rise for Boeing Launches," Seattle Post-Intelligencer, Feb 26, 2004, p. 1.

companies are not going to get rich off of this. They are going to be covering their costs."[37] U.S. Government launches now constitute as much as 90% of their current business.

U.S. Government involvement is intended not only to "save" the launch industrial base, but it averts further consolidation in an effort to keep the two space launch providers.[38] In December 2003, Deputy Defense Secretary Paul Wolfowitz signed a Program Decision Memorandum that established the policy of supporting two launch providers for the purpose of assured access to space, despite a proposal to reduce the program to one contractor.[39] The loss of the Shuttle Challenger in 1985 highlighted the dangers of relying on a sole heavy lift launch capability. For now, there appears to be no viable option except to maintain both EELV providers until one or both have established a high degree of reliability. Assured access trumps overcapacity. There remains to be articulated, however, a comprehendible definition of "assured access" and a rigorous explanation of why two domestic launch providers is the correct means to achieve it.

> **RECOMMENDATION: Revisit the national launch strategy for assured access to space.** We believe that the government should reconsider the business case for the existing national launch strategy to find a more efficient yet secure manner of guaranteeing access to space, such as backing up launches through multinational teams much as the commercial sector does. At the same time, it is appropriate for the government to continue to provide seed money for research, development and prototype testing of promising technologies and concepts.

Barriers to Entry. If the commercial space industry is to resume growth, new space applications and emerging space business ventures will be critical to its success.[40] Unfortunately, the industry is faced with numerous barriers that inhibit such growth and expansion. To encourage growth in the domestic market and ultimately reduce its own space related costs, the U.S. Government needs to take positive action to reduce entry barriers.[41] The resulting competition will increase growth and induce corresponding reductions in price. Space can be made more affordable while maintaining assured access.

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[37] Capaccio, Tony, "Payment Rates Rise for Boeing Launches," Seattle Post-Intelligencer, Feb 26, 2004, p. 1.
[38] McAlister,Philip, "The State of the Space Industry", Futron briefing, January 8, 2004.
[39] Butler, Amy, Wolfowitz Codifies Policy For Two Rocket Makers, Despite PA&E Push For One, Business and Industry, Dec 12, 2003, page 1 (LexisNexis Email). See also Morris, Jefferson, New EELV Strategy To Be In Place By Next Year, Teets Says, Aerospace Daily, December 3, 2003, pp. 1-2. (www.mcgraw-hill.com).
[40] Livingston, Dr. David M., "The Prospects for Space Commerce in the Aftermath of 9-11," Mars Society, Aug 10, 2002.
[41] Access to Space: The Future of U.S. Space Transportation Systems, Chapter 6, Reducing Space System Costs.

Subsidy. Additional funding for EELV contractors Boeing and Lockheed Martin has already been mentioned. This type of funding can act as a barrier to entry by others because it operates as a subsidy to incumbents, creating a supply of capital not otherwise available to outsiders. "The DOD may provide $1 billion in aid to Boeing and Lockheed Martin to support the fleet of Delta IV and Atlas V vehicles. They have released the first $200 million."[42] The access to U.S. Government facilities regularly granted to industry incumbents can be viewed similarly. Market participants must otherwise invest in sophisticated infrastructure and navigate strict environmental standards. It is not difficult to understand the advantages and market stabilization that such subsidies provide.[43]

Export Control. Another serious concern for the U.S. industry is the regulation of space technology exports. Many space technologies and systems are "dual-use"—they can be used for both military and commercial purposes. For example, a satellite might be able to take pictures of crops, but it can also take pictures of troop movements. For national security reasons, the U.S. controls export of dual-use technologies through the licensing process at the Department of Commerce. In reaction to a 1996 unlicensed transfer of technology to China, the U.S. Congress mandated that space technologies and equipment be switched to the more restrictive "Munitions List" maintained by the Department of State. The State Department's licensing process is much more cumbersome and includes notification to Congress when a license is about to issue. This change in treatment from "dual-use" to "munitions" has resulted in much delay and expense to the satellite industry.

European satellite manufacturers are learning to exploit this hurdle in the U.S. space industry. According to the Satellite Industry Association, America's share of the global market dropped from 64% in 1998 to 36% in 2002. The U.S. turned from a net exporter of commercial satellites and parts to a net importer. Business Week says, "Barriers to U.S. sales have spurred rivals overseas to offer a variety of satellite services, so any adversaries can easily buy imaging and communications services elsewhere. And by making U.S. companies less attractive suppliers, the rules cripple this vital industry." (This subject is more thoroughly discussed in an accompanying essay.)

RECOMMENDATION: Rework export controls to prevent unintended foreign disclosure, while allowing US companies to compete internationally. We need to rebalance the degree of export control to recognize that most space

[42] Furniss, Tim and Hoyle, Craig, "Boeing May Be Re-admitted to EELV Bidding Competition Pentagon Rules That Both Atlas and Delta Fleets Are Needed to Ensure Access To Space," *Business and Industry*, Feb 10, 2004, p. 4 (LexisNexis Email).
[43] The European Space Agency similarly has provided large amounts of funding to Arianespace.

technologies are now widely available. Some options are: 1. Curtail the congressional notification requirement, 2. Apply the Commerce Control List for exports to allies, 3. Scrub the Munitions List for technologies that are no longer unique and critical to maintain space dominance, or 4. Reverse the Congressional mandate to control satellite exports through the Munitions List.

Insurance. Satellite operators and other players in the commercial space sector must consider two forms of insurance to protect their investment: primary insurance to cover the significant risk that a launch will fail or that the satellite will not operate at full capacity on orbit, and third party liability insurance to cover the risk that someone will be harmed by launch or reentering debris. In the nature of an unintended consequence, technology transfer concerns and export license requirements operate to restrict conveyance of the technical information required by multinational insurance underwriters to assess risk. This restriction results in a reluctance by foreign underwriters to participate in U.S. space insurance syndicates. This drives insurance costs up by reducing the number of underwriters available to U.S. firms.

Space insurance accounts for a rapidly increasing slice of 8 to 15 percent of the total launch costs. Futron Corporation reports "In the [years 1997-2001], space insurance rates [rose] by 129%."[44] Some satellite operators are deciding to bear the risk of loss without insurance.

Risk management for third party liability is facilitated through the Commercial Space Launch Act (CSLA), which provides for government risk sharing beyond the coverage required of the launch provider. The CSLA contains a sunset provision, however, and is set to expire in December 2004. Failure to extend the CLSA would result in unfair competitive advantages to foreign providers whose governments continue to provide similar programs.

RECOMMENDATION: Remove the Commercial Space Launch Act (CSLA) third party indemnification sunset clause. Permanent availability of this indemnification is an important form of government support to the U.S. space industry, which needs this benefit to prevent an advantage for foreign competitors who enjoy similar provisions.

Space Acquisition Management. Space acquisition has critical cost overrun issues. Systemic space acquisition issues are evident with the news of SBIRS[45] acquisition problems and another major U.S. space acquisition program which is years behind schedule and over budget by

[44] Futron Corporation, "Satellite Insurance Rates on the Rise – Market Correction or Overreaction?" Jul 10, 2002. Retrieved from http://www.futron.com/.

[45] Space Based Infrared System. See "Air Force Prepares New, Higher SBIRS High Cost Estimate," *Defense Daily*, Mar 16, 2004.

as much as 150%. A flawed acquisition strategy can be a problem to any endeavor, but mistakes in the space industry have profound consequences due to the magnified costs and the limited quantity of articles involved. There is no real opportunity to recover from a mistake or amortize the cost of poor strategy across large production quantities.

"Bleeding edge technologies" are often used in space systems, accompanied by a heightened danger of requirements creep and cost underestimation. Successful acquisition programs perform high quality system engineering up front in order to generate sound requirements for the contractors and to provide the framework for the program managers and their staffs to execute quality, timely direction and make wise decisions. These desires can best be addressed with experienced space program acquisition leadership and "seasoned" program management talent. Program offices are losing much of their talent to better paying jobs in business or to retirement. Government offices cannot grow the talent quick enough to compensate.

RECOMMENDATION: Improve government manning and systems engineering for space acquisition by lifting the FFRDC manpower caps. Weak systems engineering manning in the government sectors seemed to be at the root of many space acquisition woes. Allowing Federally Funded Research and Development Centers to expand their manpower offerings is an expedient way to address this. We also recommend an improving the manning situation by facilitating improvement of government retention rates.

CONCLUSION

The space industry is a vital element of the global economy. Satellites provide a wide range of services and applications for the military, civilian, and commercial sectors, including telecommunications, remote sensing, and navigation. Space is critical for national security, and its crucial for our way of life.

In recent years, the demand for new satellite services has been low, resulting in overcapacity of most of the U.S. and foreign space industry markets. Unfortunately the outlook for growth in the domestic market does not look good without some action by the U.S. Government to reduce entry barriers and encourage growth. The U.S. government will continue to lead the world with its space policy, as well as to serve as the "anchor tenant" for the global space industry.

Current U.S. export controls are a significant barrier to the expansion of the U.S. space industry and have promoted the development of industry in competing countries. If the question is balance between national security and broader national space interests, national security must

and will take precedence. Moderating the control of technologies that are no longer unique or critical to maintaining space dominance, however, will better advance the nation's interests.

President Bush's January 2004 announcement of a vision for solar system exploration has stirred interest, discussion, and speculation. The vision will fail, however, without the sustained political will of the U.S. citizenry and international agency cooperation. The execution of this vision is important not only because of its potential benefit to mankind but also for the opportunity it offers for close ties with other space faring nations.

The "star" issues discussed herein will continue to evolve as we discern the degree of support for space activities and the industry is expanded by new capabilities (such as inexpensive launch). New "stars" will add their light, as the industry situation is joined by new issues (such as fiscal constraints) and human events yield clarity to the roles of nations and other world actors.

ESSAYS ON MAJOR ISSUES

U.S. SPACE TECHNOLOGY: OVERVIEW AND IMPLICATIONS

"This cause of exploration and discovery is not an option we choose; it is a desire written in the human heart." —President Bush

Introduction. This paper provides a quick review of today's most promising technologies. It will discuss today's strategic environment and the implications for the future of U.S. space technology. Capabilities gained from space technologies support commercial investments and transactions, personal finances and communications, and national prestige and security. Recently, President Bush produced "A Renewed Spirit of Discovery," his vision of a renewed focus for U.S. space exploration.[46] While U.S. space policy, infrastructure, funding, organization and technology research and development will be affected significantly by the president's vision, they must also align with domestic fiscal realities, foreign cooperation and competition, and converging commercial technology capabilities.

Promising U.S. Space Technologies. The Evolved Expendable Launch Vehicle (EELV) designs offer valuable new launch technologies. Lockheed Martin, in concert with Russia's Khrunichev State Research, has developed process improvements for the Atlas V family of vehicles. Their "clean launch platform" approach, along with networked IT systems checkout

[46] Bush, George W., "A Renewed Spirit of Discovery, The President's Vision for U.S. Space Exploration," USGPO, January 2004, p. 2.

and simple two-facility construction speeds readiness processing using remote cordless data entry. Atlas promises 24-48 hour regeneration times using fewer personnel, a significant step towards low-cost assured access.[47] Boeing has reduced payload weights through miniaturization of electronics and reduced power requirements for the Delta IV family of launch vehicles.[48] Sea Launch systems have designed a unique launch service by combining horizontal Zenit-3SL rocket assembly operation aboard a command ship, with a launch platform based on a North Sea oil-drilling platform. This one-of-a-kind capability enables spacecraft launch directly into low earth orbits of any inclination, taking maximum advantage of the earth's rotational speed. Components are manufactured in Russia, Ukraine, and Seattle.[49]

Spacecraft components represent the most rapidly advancing segment of the space industry. Radioactive isotope decay has powered deep space craft for years with thermo-electric generators called RTGs. These RTGs use 24 pounds of plutonium dioxide pressed into 72 ceramic marshmallows. The half-life of the material is 87 years, so it can produce large amounts of electricity for long periods, in regions of space where there is little solar energy. Lockheed Martin has recently improved upon the RTG by using vibrating pistons to extract the same energy from a smaller amount of plutonium. NASA plans to use the Stirling Radioisotope Generator (STG) for its Mars lander in 2009 and its Jupiter Icy Moons Orbiter (JIMO) program under NASA's Project Prometheus. The craft will conduct a robotic tour of Jupiter's icy moons in 2015. Advantages of higher power supply include the ability to use active radar and increased bandwidth communications in addition to passive instruments like cameras and spectrographs.[50]

Lockheed Martin's Solar Dynamics observatory (SDO) will measure visible through X-ray spectrum solar emissions. By analyzing the seismic and magnetic effects on the earth's heliosphere, it will give scientists the ability to predict the severity of solar events and their potential hazard to humans and machines. One of SDO's significant improvements over older generation observers is the sheer quantity of data it will transmit—about 1,500 Gigabits each day.[51] Spin-off technologies from solar probe developments include radiation hardened microchips and new ceramic thermal barriers. Satellites able to withstand up to 4 Million Rad under large thermal gradients have clear applications to survivable military spacecraft.[52]

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[47] Briefing by Lockheed employee, Patrick AFB, 4 Mar 2004.

[48] Briefing by Boeing employee, Patrick AFB, 4 Mar 2004.

[49] "Sea Launch System-Commercial Heavy-Lift Launch Services, USA," www.space-technology.com/projects/sealaunch, Mar 2004.

[50] "NASA's Nuclear Future," http://www.space.com/businesstechnology/technology/nuclear_focus_040218-1.html, Mar 2004.

[51] Yachbes, Irene, "The Next Great Sun-Watching Spacecraft," http://www.space.com/businesstechnology/technology/sdo_tech_040324-1.html, Mar 2004.

[52] Briefing by Johns Hopkins University Applied Physics Lab, 20 Feb 2004.

Laser (optical) communications will increase bandwidth to enable transfers of such large amounts of data. Ball Aerospace has proven transfer rates of 50 Gigabits per second, with much higher potential rates possible through "splitting" of the light bands using prisms and filters.[53]

Lockheed Martin, Hughes, and TRW have teamed to produce the $2.5B Advanced Extremely High Frequency (AEHF) MILSATCOM program. New software codes have enabled better frequency hopping and encryption techniques. The first of five satellites will be launched into Molniya orbit in late 2004, providing reliable, jam-resistant, secure comm. for the warfighter.[54]

NASA's Jupiter Icy Moons Orbiter (JIMO) program makes use of the U.S. Navy's nuclear knowledge and safety record to help design and build a compact nuclear reactor. It would be used to power ion engines on board the deep space probe JIMO. One technical challenge is that the Europa lander must remain cool enough to avoid melting ice on the surface. This environmental hurdle has unofficially slipped the JIMO launch schedule from 2011 to 2015.[55]

NASA's JPL has developed the Microarcsecond Metrology Testbed (MMT). It uses the interference in the waveforms of light coming from distant stars in order to find a miniscule micro-arcsecond "wobble" in a distant star. The wobble represents the gravitational influence of an orbiting planet, and MMT's accuracy (1,000 times better than last generation) will allow scientists to find smaller earth-size planets for the first time.

Policy and Funding. The President's vision outlines several objectives which drive space policy and organization: an "affordable human and robotic program to explore the solar system and beyond" to "develop innovative technologies," and to "promote international and commercial participation."[56] In light of this direction, the Office of Science and Technology Policy (OSTP) within the Executive Office of the President is reviewing National Security Presidential Directive 15 and U.S. Commercial Remote Sensing Policy to ensure they align with the President's vision. OSTP goals include national security, economic competitiveness, science and technology capability, and private and international cooperation.[57] These sometimes-conflicting goals must be resolved in actual application by the Departments of Commerce (DOC) and State (DOS).

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[53] Ball Aerospace, http://www.ball.com/aerospace/pdf/lasercom.pdf, and Space Technologies News, http://www.wired.com/news/technology/0,1282,54190,00.html, Mar 2004.

[54] Industry Projects, http://www,space-technology.com/project_printable.asp?ProjectID=2017, 21 Mar 2004.

[55] David, Leonard, "Navy May Help NASA Build Nuclear Reactor for Jupiter Mission," http://www.space.com/businesstechnology/technology/jimo_fin_040219, 19 Feb 2004.

[56] Bush, George W., "A Renewed Spirit of Discovery, The President's Vision for U.S. Space Exploration," USGPO, January 2004, p.4.

[57] Briefing by a Senior Policy Analyst in the Office of Science and Technology Policy, Executive Office of the President, 6 Feb 2004.

DOC has placed its priority on building U.S. economic strength through grants to industry to develop technology, while significantly restricting export licensing/technology exportation.[58] The Non-Proliferation Bureau within DOS has a slightly different focus. They argue that the relative U.S. vs. foreign technology level is important in determining the utility of export control. If the tech level is close, it may be more advantageous to get U.S. firms *into* the international market while we still have the competitive advantage. This would stimulate U.S. economic growth, enable soft intelligence from their use of U.S. technology, and enable the U.S. to control the market by deterring new entrants.[59]

In response to a Presidential Commission on implementation of this policy, NASA has moved from a function-based, stovepipe approach, to a mission-based strategy. Exploration technologies will receive a 5.6% budget growth next year, and technology development's share of NASA's budget is projected to grow from 23.9% today to 62% in 2014.[60] R&D funding has shifted from commercial to mostly NASA applications.[61] Boeing and Lockheed Martin now view commercial R&D as "a nice supplement to military, rather than the big moneymaker." Northrop-Grumman seems better positioned to take advantage of NASA R&D growth, as they never had much presence in the commercial business.[62] Clearly, government dollars are the lifeline of the space industry's R&D community today.

Personnel Issues. Total level of effort, funding, and manpower demands for R&D have remained stable or slightly increasing, mostly due to government increases at least making up for commercial losses. Manpower requirements have been predictable and easily met, though with an increasing proportions of resident aliens.

NASA is the largest provider of technology education, offering facilities, infrastructure, human resources and information to support six dedicated and seven other current educational programs, reaching 37 million people. [63] Their Space Science Education/Public Outreach program establishes four educational forums and five regional facilitators.[64] Overall, funding for space science education is decreasing as a percent of NASA's budget, however, and national test scores for math and science continue to decline.

Demographic trends show a shifting picture. Fifty- and sixty-something white males dominate the top of the industry, while young and predominantly foreign nationals gain entry-

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58 Briefing by DOC representative, 23 Feb 2004.
59 Briefing by DOS representative, 23 Feb 2004.
60 Briefing by NASA employee, 19 March 2004.
61 Briefing by Johns Hopkins representative, 20 Feb 2004.
62 Caceres, Marco Antonio, "Satellites: Hope on the Horizon?" *Aviation Week and Space Technology*, 19 January 2004.
63 "Education," NASA Headquarters handout FS-2000-01-011-HQ, 6 Feb 2004.
64 "Space Science Education/Public Outreach," NASA Headquarters handout FS-2000-04-017-HQ, 6 Feb 2004.

level positions. Health care and retraining costs are growing, but may peak within 10 years and fall with the retirement of large numbers of aging personnel.

Priorities. While NASA and the USAF see a need for small satellites to provide assured access and to lower launch costs, commercial satellite manufacturers and users look to the bottom line, and it is capability per dollar. When measured this way, large satellites may provide more bang for the buck due to current high fixed overhead and launch costs. Only when Space Exploration Technologies has proven the reliability and advertised $6M launch costs of its Falcon rocket will government and commercial priorities begin to merge.[65]

Recommendations and Conclusion. The U.S. space R&D industry maintains "bleeding edge" technology and significant competitive advantage. Much of this is due to collaborative efforts between government, industry, and academia. I recommend we continue this teaming approach, but also include international partners whenever economic and security realities will allow. We should fund those technologies offering the largest returns. For example, while computation, data storage and transfer technologies have improved several orders of magnitude in the last 20 years, chemical propulsion technologies have made only marginal performance improvements. Yet, we continue to measure launch costs per pound, rather than per capability. Technology transfer should favor the DOS model, evaluating the technology gap and basing proliferation decisions on multiple effects. The U.S. should take the long view with education, even to the point of cutting existing social welfare programs to increase future U.S. competitive capability. We should mortgage the past to pay for the future, rather than vice-versa.

—Lt Col Joseph L. Lenertz, USAF

EXPORT CONTROLS STRANGLE SATELLITE INDUSTRY WITH RED TAPE

> *"A policy designed to deprive America's potential enemies of advanced spying and communications technology while protecting America's hardware edge has been ruinous on both counts." —Business Week*

Introduction. In 1998, congressional concerns over alleged leaks of weapons and missile technologies to China led to legislation transferring the export-licensing jurisdiction for satellites from the Department of Commerce to the Department of State. Under the State Department

[65] "Eyeing Cost Savings, US Air Force Widens Door for Small Sats," www.defensenews.com, 1 Mar 2004, and NASA briefing, Marshall Space Flight Center, 18 Mar 2004.

system, satellite companies now must apply for thousands of additional licenses.[66] The State Department's tight controls are criticized heavily due to the "snail-like pace of gaining export licensing approval."[67] "[T]he export control changes … [are] eroding the commercial industrial base through loss of sales."[68] Moderation of the satellite export controls is vital to "avoid what looks like strategic suicide."[69]

Export Controls. The U.S. has interests in both promoting and regulating the export of goods, services, and information. Of particular governmental interest is the export of armaments and items that have a "dual-use" for military and civilian purposes; they are the subject of specific legislation and implementing regulations. Export of armaments is the subject of the Arms Export Control Act[70] and the State Department's International Traffic in Arms Regulation (ITAR),[71] forming a licensing system intended to be rigorous and careful. "Dual-use" items are covered by the Export Administration Act[72] and the Commerce Department's Export Administration Regulations.[73] The Commerce process is designed to facilitate exports. Since the early 1990's, satellites had been considered dual-use items and export licensing was conducted under the Commerce Department's process.

Stimulus to Change. Following the 1989 Tiananmen Square massacre, the U.S. imposed numerous trade barriers on China, among them adding a presidential waiver requirement to export satellites to China, for launch or for sale. Despite the overall intent to sanction, the prospect of a presidential waiver allowed American companies to access China's cheaper commercial launch prices.[74]

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[66] "Satellite Industry Association's Executive Director Calls for US Government to Speed Up Export Licensing," *Satellite News*, Sep 25, 2000.
[67] "Satellite Export Licensing Should Go Back to Commerce Department, Panel Recommends," *Satellite News*, Sep 18, 2000.
[68] Preserving America's Strength in Satellite Technology, Center for Strategic and International Studies, April 2002.
[69] Crock, Stan, "What's Shooting Down Satellite Sales: Congress needs to refine strict licensing rules meant to keep unfriendly states from buying US technology," *Business Week*, Aug 4, 2003, p. 80.
[70] 22 U.S.C. 2751, http://www4.law.cornell.edu/uscode/22/ch39.html.
[71] The ITAR and other relevant material can be accessed online at http://pmdtc.org/reference.htm.
[72] "The Export Administration Act of 1979, as amended, has been in lapse since August 21, 2001. In the absence of an Export Administration Act, the US dual-use export control system continues to be dependent on the President's invocation of emergency powers…." See http://www.bxa.doc.gov/eaa.html.
[73] Export Administration Regulations can be accessed online at http://w3.access.gpo.gov/bis/index.html.
[74] China's cheaper space launch prices ranged from $12-70 million compared with US prices ranging from $50-100 million. Fisher, Richard D., Jr., "Commercial Space Cooperation Should Not Harm National Security," The Heritage Foundation Backgrounder, No. 1198, Jun 26, 1998.

On February 15, 1996, a Chinese Long-March 3B rocket crashed soon after liftoff, carrying with it the Intelsat 708 satellite made by Loral Space & Communications.[75] Chinese aerospace specialists performed an investigation and identified a cause of the failure. "International insurance companies, however, raised serious doubts about their continued coverage of the Long-March launch vehicles. They demanded that China allow an independent review panel to assess the conclusion of the Chinese investigation. Without such a review, as they argued, it would be difficult for them to continue providing insurance coverage."[76]

Under this pressure and with a healthy launch manifest pending, China uncharacteristically permitted an Independent Review Committee (IRC) to investigate the launch failure. Loral and Hughes Electronics Corp. assisted with the investigation, identifying alternate failure causes. A Loral employee "mistakenly" sent a copy of the IRC report to the Chinese government.[77] Prompted by an alert Defense Technology Security Administration analyst, Loral made a "voluntary" disclosure[78] to the U.S. State Department. The State and Defense departments both investigated the disclosure.[79] They concluded the technology transferred could have harmed national security.[80]

Congressional Actions. Meanwhile, certain factions surrounding Capitol Hill who regularly wish China ill[81] spotted the transactions described above, and further noted that Loral Chairman

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[75] Loral had obtained two export licenses from the State Department to allow the launch of the Intelsat 708 satellite in the PRC. Neither of those licenses authorized any launch failure investigative activity.

[76] Press Release, "A Review of China's Launch Services for US-Made Satellites," Embassy of the People's Republic of China, No. 98-12, Jul 17, 1998.

[77] Loral pointed out that the employee had attempted to delete all sensitive material before sending the report. Nonetheless, Loral accepted "full responsibility" for the matter and its failure to obtain regulatory approval to share the report with the Chinese. In January 2002, Loral settled the case with the US Government, agreeing to pay $14 million in fines over seven years, and adding another $4 million to the $2 million already spent strengthening its export compliance program. See "Loral Clears Hurdle With Settlement," *Satellite News*, Jan 14, 2002.

[78] The reports languished in government files for nearly 18 months; the Clinton administration said it was just a normal bureaucratic delay. But congressional investigators wanted to know if administration officials sat on the reports to avoid embarrassing China or Loral CEO Bernard Schwartz, a major Democratic Party contributor.

[79] The Defense Department concluded that "Loral … committed a serious export control violation by virtue of having performed a defense service without a license …." The State Department referred the matter to the Department of Justice for possible criminal prosecution.

[80] The technical issue of greatest concern was the exposure of the PRC to Western diagnostic processes, which could lead to improvements in reliability for all PRC missile and rocket programs.

[81] See about the "Blue Team" generally: Kaiser, Robert G. and Mufson, Steven, "Blue Team Draw a Hard Line on Beijing**:** Action on Hill Reflects Informal Group's Clout," *The Washington Post*, Feb 22, 2000, p. A1, available online at http://www.againstbombing.org/chinahands.htm, and Waller, J. Michael, "Blue Team Takes on Red China," *Insight on the News*, Jun 4, 2001, available online at http://www.findarticles.com/cf_dls/m1571/21_17/75348385/p1/article.jhtml, and other sites. The highly charged political context of 1998 is an important consideration. President Clinton was being impeached, and Year of the Rat:

and CEO Bernard L. Schwartz was the largest single contributor to the Democratic National Committee in 1996. The opportunity to investigate could not be ignored. Reps. Christopher Cox (R-CA) and Norm Dicks (D-WA) were named to lead a House select committee to determine (among other things) whether Loral and Hughes transferred information to China, damaging U.S. national security or enhancing Chinese ballistic missile capabilities.[82]

The "Cox Committee" concluded in January 1999 that such incidents had compromised national security, and unanimously recommended that the State Department be solely responsible for licensing satellites.[83] By then, Congress had already ordered[84] the switch from Commerce.[85]

What Changed? For the 10 years prior to the transfer of authority from Commerce to State, U.S. satellite manufacturers dominated their competition by capturing three quarters of the global market.[86] "After the tough export rules took effect, America's share of global satellite sales plummeted from 64% of the $12.3 billion market in 1998 to 36% of the $12.1 billion market in 2002, according to the Satellite Industry Assn. And the U.S. turned from a net exporter of commercial birds and parts to a net importer. "[87]

"Companies are … reporting that their customers perceive licensing problems in the U.S. and not Europe. That puts us at a disadvantage," said Clayton Mowry, [former] Executive Director of the Satellite Industries Association (SIA)."[88] European satellite builders are exploiting the licensing problem with U.S. satellites when trying to gain contracts, and they have gained a lion's share of the new contracts.[89]

Doug Heydon, (former) chairman of Arianespace Inc., said "the change in licensing responsibility was a "knee-jerk reaction" to the "hysteria" of the Cox Report. "One of the biggest problems … is the need for congressional notification of each license," Heydon said. "That

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How Bill Clinton Compromised US Security for Chinese Cash was published accusing him of treason for the benefit of his campaign fund. The coincidence of a large campaign donor (Schwartz), the presidential waivers benefiting the donor's corporation, and transfer of satellite technology in violation of export control laws was too much to ignore. For a "Blue Team" intent on building China into our next enemy, their day had arrived—and apparently has not yet departed.

82 Goodrich, Lawrence J., "Plaudits for impresarios of next house inquiry," *Christian Science Monitor*, Jun 29, 1998.

83 See Report of the Select Committee on US National Security and Military/Commercial Concerns with the People's Republic of China, available online at http://www.house.gov/coxreport/, May 25, 1999.

84 Public Law 105-261, Strom Thurmond National Defense Authorization Act for Fiscal Year 1999, §§ 1511-1516, Oct 17, 1998.

85 Goodrich, *Christian Science Monitor*.

86 *Satellite News*, Sep 25, 2000.

87 Crock, Stan, "What's Shooting Down Satellite Sales: Congress needs to refine strict licensing rules meant to keep unfriendly states from buying US technology," *Business Week*, Aug 4, 2003, p. 80.

88 *Satellite News*, Sep 25, 2000.

89 *Satellite News*, Jan 14, 2002.

requirement leads to especially long delays for license approvals; when Congress is out of session they cannot be notified that an export license is ready to be issued."[90]

Conclusions. The imposition of a stricter export-licensing regime has greatly increased the costs to suppliers of components, satellites, and launchers. Far beyond the direct costs to expand and train a staff for license preparation and pursuit, there are costs of schedule uncertainty and delay, and increased overhead allocations for the reduced quantities demanded. Taxpayers bear additional costs staffing the agencies to shoulder the increased license review burden.

Second-order consequences, however, are of greater concern: U.S. technology is not acquired—or developed; foreign technology is developed and acquired instead.[91] As the largest provider of U.S. exports, the aerospace sector is the "last crown jewel" of heavy industry in the country, says John Douglass, president and CEO of the Aerospace Industries Association.[92]

"Satellites are Exhibit A in the case against Washington's quixotic attempt to regulate exports of widely available commercial products. The global spread of technology has rendered almost all such efforts obsolete. … The barriers to U.S. sales have spurred rivals overseas to offer a variety of satellite services, so any adversaries can easily buy imaging and communications services elsewhere. And by making U.S. companies less attractive suppliers, the rules crippled an industry [on which] the Pentagon wants to rely…."[93]

Combined with overcapacity, emergent foreign competition, and low rates of return on equity, the 1998 change in export regulations accelerates the demise of many firms by increasing uncertainty and reducing profitability. The deteriorating financial health of the satellite industry poses a threat to the defense industrial base and our national security.[94]

Recommendations. "Technology [export] restriction was effective when the U.S. had a near monopoly on advanced satellite technology. The U.S. still has some unique satellite technologies where restriction remains appropriate, but as technological capabilities have spread around the world, this has become a very small set of items."[95] The U.S. needs to distinguish those satellite technologies that are routine, commercial, and available from foreign sources, and remove the export controls—they convey no benefit.

Several approaches could improve the situation, either alone or in combination:

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[90] *Satellite News*, Sep 18, 2000.
[91] This conclusion was confirmed by European Space Agency officials during discussions on May 6, 2004.
[92] "AIA Foresees Export Reform, Creation of Presidential Commission on US Aerospace," *Satellite News*, Dec 18, 2000. Congress has already tried to improve export license processing by providing additional funding to the State Department. *Satellite News*, Jan 14, 2002.
[93] Crock, *Business Week*.
[94] Preserving America's Strength in Satellite Technology, Center for Strategic and International Studies, April 2002.
[95] Ibid.

- Curtail the congressional notification requirement, defaulting to notifications only for exports above certain dollar values or "major defense articles;"[96]
- Apply the Department of Commerce licensing regime (instead of the State Department regime) for satellite exports to NATO and non-NATO allies;
- Scrub the list of technologies that are no longer unique and critical to maintaining our space dominance, and return those portions to the Commerce Department; or
- Reverse the mandate to control satellite exports through the Munitions List in favor of controls through the Commerce Control List.

Numerous industry representatives have been working to effect some change, as it is abundantly clear that change is appropriate. Despite the regular proposal of amending legislation and the effort of 360 meetings between industry lobbyists and Capitol Hill staffers during 2001, none could end the impasse over the issue.[97]

The newly arrived Rich DalBello, Executive Director of the SIA reported, "The core of our strategy has been to explain that the satellite export issue is not about choosing between national security and a competitive U.S. satellite industry. It is possible to keep all of the national security safeguards put in place in 1998 while enjoying the relative speed and certainty of the Commerce licensing process. … Essentially, we have the entire U.S. aerospace industry on the same page on this issue and we believe that the actions we are proposing will serve to strengthen the U.S."[98]

—Col Robert W. Ramsey III, USAF

U.S. COMMERCIAL REMOTE SENSING INDUSTRY

> *"Commercial observation satellites are emblematic of information age technologies at the start of the new millennium; they promise to bolster global transparency by offering unprecedented access to accurate and timely information on important developments." —John C. Baker, et al.*

Introduction. The legal framework for licensing and regulating the commercial space remote industry was established by the *Land Remote Sensing Act of 1992*.[99] Presidential Decision Directive 23 (PDD-23 *Foreign Access to Remote Sensing Space Capabilities*, March 9, 1994

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[96] The Arms Export Control Act (AECA) requires the President to notify Congress of all proposed exports of major defense equipment valued at more than $14 million and exports of defense articles and services exceeding $50 million. Once notified, Congress can pass a joint resolution prohibiting the export of that article within 15 calendar-days for exports to NATO-plus countries (NATO, Japan, Australia, and New Zealand) and 30 calendar-days for exports to all other countries.

[97] Crock, *Business Week*.

[98] *Satellite News*, Oct 1, 2001.

[99] United States, U.S. Congress, Land Remote Sensing Policy Act (P.L 102-555), October 28, 1992.

followed this legislation. The goal of this policy was "to support and to enhance U.S. industrial competitiveness in the field of remote sensing space capabilities while at the same time protecting U.S. national security and foreign policy interests."[100] Space remote sensing is the sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects.

There are currently three U.S. commercial companies operating remote sensing satellites: Space Imaging of Denver, Colorado; DigitalGlobe (formerly Earthwatch) of Longmont, Colorado; and Orbimage of Dulles, Virginia. Orbimage was founded in 1991 and company currently operates the OrbView-2 (1.1 km. Resolution) ocean and land imaging satellite (launched in 1997), and the OrbView-3 high-resolution (1m panchromatic and 4-m multispectral) digital imagery imaging satellite launched on June 26, 2003.[101] DigitalGlobe, formerly EarthWatch, was founded in 1993 and launched its Quickbird satellite on October 18, 2001.[102] The Quickbird satellite is the highest resolution satellite imagery available to the commercial market, up to 61-cm (2-ft) panchromatic and 2.44-meters (8-ft) multispectral.[103] Space Imaging was founded in 1994 and became the first commercial company to deploy a high-resolution satellite, the IKONOS. [104] The IKONOS satellite collects black-and-white (panchromatic) images with 1-meter resolution and multispectral imagery with 4-meter resolution. [105] Space Imaging also acquired EOSAT from Lockheed Martin, the commercial company responsible for operating and selling data from Landsats 4 and 5.

Commercial Remote Sensing Policy. A new *U.S. Commercial Remote Sensing Policy* was issued by the President Bush on April 25, 2003. The new policy supersedes PDD-23 and provides guidance for: the licensing and operation of U.S. commercial remote sensing systems; U.S. Government use of commercial remote sensing capabilities; foreign access to U.S. commercial remote sensing capabilities; and government-to-government intelligence, defense, and foreign policy relationships involving U.S. commercial remote sensing space capabilities.[106] The goal of this policy was "to advance and protect U.S. national security and foreign policy interests by maintaining the nation's leadership in remote sensing space activities, and by sustaining and enhancing the U.S. remote sensing industry."

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[100] United States, The White House, "Presidential Decision Directive 23 (PDD-23): Foreign Access To Remote Sensing Space Capabilities," March 10, 1994.
[101] Orbimage, Inc., www.orbimage.com/corp/index.htm.
[102] DigitalGlobe, Inc., www.digitalgobe.com.
[103] Ibid.
[104] Kevin O'Connell and Greg Hilgenberg, "U.S. Remote Sensing Programs and Policies," Commercial Observation Satellites, RAND and ASPRS, 2001, p. 151.
[105] Space Imaging, www.spaceimaging.com.
[106] United States, White House, "U.S. Commercial Remote Sensing Policy," April 25, 2003.

Licensing and Controls. Licensing and regulating the commercial remote sensing industry is the responsibility of the Secretary of Commerce, who has delegated that authority to the National Oceanic and Atmospheric Administration's (NOAA).[107] The responsibility for determining the conditions necessary to protect national security and foreign policy concerns is assigned to the Secretary of Defense and the Secretary of State, respectively.[108] Within DoD, the National Geospatial-Intelligence Agency (NGA) is responsible for acquiring and disseminating commercial remote sensing space products and services for all national security requirements and foreign policy requirements."[109]

Developing Government and Industry Relationships. In response to the President's new remote sensing policy, the Director of Central Intelligence (DCI) directed NGA in June 2002 to use U.S. commercial satellite imagery as the primary source for government mapping. Under the *ClearView* program, NGA awarded contracts to DigitalGlobe, Space Imaging, and Orbimage.[110] The *ClearView* contracts are multi-year contracts; a three-year guaranteed contract with options for two additional years and has a ceiling of $500 million. *ClearView* includes broad licensing agreements that allow distribution of the imagery to all government branches, departments, agencies, and offices. Under the *NextView* program, NGA also awarded a five-year contract to DigitalGlobe to assure the availability of high-resolution imagery from the next series of U.S. commercial imagery satellites.[111] The *NextView* contract allows early participation in the development for the next generation of U.S. commercial satellite imaging capabilities, and seeks to assure access, priority tasking rights, volume (area coverage) and broad licensing terms for sharing imagery with all potential mission partners."

Market Forces—Foreign and Domestic. Although the imagery from U.S commercial remote sensing satellites has numerous commercial applications, demand both domestically and internationally has been low. Domestically, the commercial remote sensing industry competes with commercial aircraft imaging. The commercial aircraft imaging industry is older than the remote sensing satellite industry and has a broad clientele. In addition, other countries, including

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[107] United States, White House, "U.S. Commercial Remote Sensing Policy," April 25, 2003, p. 2.
[108] United States, Department of Commerce, National Oceanic and Atmospheric Administration, "Licensing of Commercial Remote Sensing Satellite Systems," www.licensing.noaa.gov.
[109] United States, White House, "U.S. Commercial Remote Sensing Policy Fact Sheet," April 25, 2003, p. 2.
[110] Ibid.
[111] National Geospatial-Intelligence Agency, "Media Release OCRP-03-12: NIMA Reinforces Its Commitment to Remote-Sensing Industry," September 30, 2003, www.nga.mil.

France, Russia, Canada, China, Brazil, Israel, India, and Turkey are operating, or have plans to operate, commercial remote sensing satellites or sell imagery from their government satellites.[112]

The entry into the commercial remote sensing market by U.S. companies has been is precarious and costly. The cost of satellites, launch services, ground infrastructures, and insurance are in the hundreds of millions of dollars. Each of U.S. companies has suffered losses of satellites during their history. Because of the large contracts with NGA, the outlook for the U.S. commercial remote sensing industry is brighter. However, the long-term commitment of the U.S. Government to the industry will be crucial to its survival.

National Security Implications. The proliferation of commercial remote sensing satellites, especially high-resolution satellites, has both benefits and risks to national security. Commercial remote sensing imagery, unlike imagery from intelligence satellites, can support a number of applications, including military, coalition efforts, diplomatic efforts, and homeland security.[113] However, the growing worldwide access to high-resolution satellite imagery will lead to a new era of global transparency and present U.S. planners with new security risks. These risks must be considered when developing future strategic and operational military plans.

Conclusions. The first decade for commercial remote sensing has been sluggish but the next decade may be more promising due to the new *U.S. Commercial Remote Sensing Policy (April 25, 2003)*, that clearly supports the development of the remote sensing space industry. As a result of this new policy, U.S. commercial remote sensing imagery is becoming a major source of data for DoD through the large contracts with NGA. The growth of the U.S. commercial remotes sensing industry will present new national security benefits and challenges.

—Mr. Bruce A. Lillegard, National Geospatial-Intelligence Agency

SPACE WEAPONIZATION: OUTER LIMITS OF OUTER SPACE

> *An attack on elements of U.S. space systems during a crisis or conflict should not be considered an improbable act. If the U.S. is to avoid a "Space Pearl Harbor" it needs to take seriously the possibility of an attack on U.S. space systems. The nation's leaders must assure that the vulnerability of the United*

[112] Ager, Thomas P., "Notes on International Remote Sensing," Geomatics an Integrated View, National Geospatial-Intelligence Agency, Bethesda, Maryland.
[113] Baker et al, Commercial Observation Satellites, RAND and ASPRS, 2001.

> *States is reduced and that the consequences of a surprise attack on U.S. space assets are limited in their effects.*[114]
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> *—Report to the Commission to Assess United States National Security Space Management and Organization*

Introduction: The Road from Exploration to Weaponization. From the outset of our foray into space under President Eisenhower,[115] U.S. attitudes concerning militarization of space have been generally cautious. International agreements and treaties have sought to regulate and limit military space activities. Historically, space-based military assets have been passive (navigation, reconnaissance, communications) as national leaders have extolled the distinction between militarization and weaponization. However, in today's technological environment, space assets are no longer limited to warning and treaty monitoring. Today's assets are critical to "real-time enhancement" of the battlefield, making it increasingly difficult to distinguish between offensive and defensive space weapons.[116]

DoD's Trend Towards Weaponization. The inherent vulnerability of our space systems is incontrovertible, making them an attractive target of asymmetric threats by hostile states and non-state actors. The significant national security value of space systems demands that we address this emerging threat and formulate a feasible national strategy to defend and protect our space systems.[117]

The unmistakable trend within DoD is toward weaponizing space. First, the 2001 *Rumsfeld Commission Report* concludes that weaponization is inevitable: "…we know from history that every medium—air, land and sea—has seen conflict. Reality indicates that space will be no different. Given this virtual certainty, the U.S. must develop the means both to deter and to

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114 Report to the Commission to Assess United States National Security Space Management and Organization, Washington DC: Commission to Assess United States National Security Space, January 11, 2001, p. ix (hereafter referred to as the Rumsfeld Commission).

115 See Krepon, Michael and Christopher Clary, Space Assurance or Space Dominance? The Case Against Weaponizing Space, The Henry L. Stimson Center (2003), p. 89; Moore, Mike, Space cops: Coming to a Planet Near You! Bulletin of the Atomic Scientists. Chicago: Nov/Dec 2003. Volume 59, Issue 6, at p. 46; Weidenheimer, Randall S., Increasing the Weaponization of Space: A Prescription for Further Progress, Air University: Air War College (April 1998), at pp. 66-67.

116 In Krepon, Space Assurance or Space Dominance? The Case Against Weaponizing Space, at page 67, the authors note that the "[m]idcourse ballistic missile defense interceptors able to reach altitudes of 1,000 to 2,000 km could also be used as ASATs against satellites in LEO."

117 Bell, Thomas D., Weaponization of Space: Understanding Strategic and Technological Inevitabilities, Center for Strategy and Technology, Air War College (January 1999).

defend against hostile acts in and from space. This will require superior space capabilities."[118] Although the commission fell short of expressly advocating weaponization of space, one of the commission's seven objectives is "power projection in, from, and through space."[119] Second, Peter Teets, DoD's Executive Agent (EA) with DoD-wide authority over the national security space program,[120] assessed in July 2003 that if "America doesn't weaponize space, an enemy will."[121] Finally, this trend is similarly supported in the carefully worded Air Force's *Vision 2020*[122] and the *Air Force Space Command' Strategic Master Plan FY06 and Beyond.*[123]

Taken together, it is clear that national security strategy is driven toward development and deployment of offensive space weapons. In fact, in today's rapidly changing space environment, it may be impossible to do otherwise as advancing technology blurs the distinction between defensive and offensive space weapons.[124]

Legal Impediments to Space Weaponization. The bulk of the law of outer space (*corpus juris spatialis*) is from international treaties to which the U.S. is a party. A key aspect of these treaties—and of international law—is that compliance during war is optional.[125] The significant treaties are:

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[118] Report to the Commission to Assess United States National Security Space Management and Organization, Washington DC: Commission to Assess United States National Security Space, January 11, 2001, (hereafter referred to as the Rumsfeld Commission), p. x.
[119] Rumsfeld Commission, p. xvi.
[120] Teets is described as a "long-standing proponent of weaponizing space." See Profile on Peter Teets at http://rightweb.irc-online.org/ind/teets/teets_body.html (as of 3 May 2004)
[121] Kelly, Jack, *U.S. the Leader in War Plans for Space*, Pittsburgh Post Gazette, July 28, 2003 (from the web at http://www.post-gazette.com/pg/pp/03209/206343.stm as of 3 May 2004).
[122] In the section labeled "Core Competencies," it states that the Air Force will "continue to develop the ability to control space when need be, assuring our ability to capitalize on space's advantages" and that the Air Force will "provide the ability to find, fix, assess, track, target and engage anything of military significance, anywhere." (See http://www.af.mil/library/posture/vision/vision.pdf)
[123] The plan defines "Space Force Application (SFA)" as the capability "to execute missions with weapons systems operating from or through space which hold terrestrial targets at risk." (See p. 2) Listed as a "Far-Term" objective is deployment of "space and missile combat forces in depth, allowing us to take the fight to any adversary in, from, and through space, on-demand." (See p. 11) (http://www.cdi.org/news/space-security/afspc-strategic-master-plan-06-beyond.pdf)
[124] Krepon, *Space Assurance or Space Dominance? The Case Against Weaponizing Space*, p. 71. For example, a satellite with propulsion capabilities enabling it to evade an attack vehicle could become a kinetic space weapon if used offensively against another space object. Or a preemptive laser defense capability could easily become a preemptive offense capability.
[125] Weidenheimer, Randall S., *Increasing the Weaponization of Space: A Prescription for Further Progress*, Air University: Air War College (April 1998), at pp. 79-81.

Limited Test Ban Treaty (1963):[126] Prohibits "any nuclear weapon test explosion, or any other nuclear explosion" in outer space.

Outer Space Treaty (1967):[127] Sets the foundation for international legal order in space. The first three articles establish the framework for the peaceful exploration and use of outer space: (1) exploration and use "shall be carried out for the benefit and in the interests of all countries… and shall be the province of all mankind"; (2) space "shall be free for exploration and use by all…"; (3) space "is not subject to national appropriation…"; and (4) exploration and use of outer space shall be "… in accordance with international law, including the Charter of the United Nations." Article IV restricts nuclear and weapons of mass destruction in space and declares that the "moon and other celestial bodies shall be used… exclusively for peaceful purposes."

Environmental Modification Convention (1980):[128] Prohibits all hostile actions that might cause long-lasting, severe, or widespread environmental effects in space.

Law of Armed Conflict (LOAC). Unlike the preceding treaties and agreements, LOAC applies to the use of space weapons at all times, including a time of war. Although LOAC does not prohibit space weapons, such weapons must comply with the LOAC principles of military necessity, avoid unnecessary suffering, proportionality, and chivalry.

(There are other significant international agreements that merit consideration.[129])

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[126] Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (http://www.fas.org/nuke/control/ltbt/text/ltbt2.htm)

[127] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (http://www.oosa.unvienna.org/SpaceLaw/treaties.html)

[128] Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (**http://www.fas.org/nuke/control/enmod/text/environ2.htm**)

[129] Other significant international agreements to consider are as follows:

Rescue Agreement (1968). This international agreement creates an affirmative duty to search for, rescue, and unconditionally return astronauts to the launching authority at no expense. (See Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space available at http://www.oosa.unvienna.org/SpaceLaw/treaties.html)

Liability Convention (1972). The Liability Convention specifies the conditions under which liability is to be assessed and compensation paid for damage caused by space objects. Basically, the convention imposes strict liability on the "launching State" for damage caused by its space objects on the surface of the Earth or to aircraft flight, and for any damage caused in space. (See Convention on International Liability for Damage Caused by Space Objects available at http://www.oosa.unvienna.org/SpaceLaw/treaties.html)

Registration Convention (1975). This convention compels all States to acknowledge responsibility for space objects by requiring registration in a registry maintained by the "launching State" which is then provided to the central registry of the UN. (See Convention on Registration of Objects Launched into Outer Space available at http://www.oosa.unvienna.org/SpaceLaw/treaties.html)

Moon Agreement (1979). This agreement attempts to establish the Moon and other celestial bodies as a new type of territory under international law (i.e., "the common heritage of mankind") and, therefore, prohibits national appropriation "by any claim of sovereignty, by means of use or occupation, or by any other means." (See Agreement

Political Impediments. The concept of deploying space weapons, even defensive weapons, is a controversial one.[130] There is simply no national consensus defining the outer limits of space weapons; one can easily find sharply divided opinions among political, academic, and scientific communities.[131] Surprisingly, the provocative public statements of national leaders—military and political—have not triggered the sort of widespread public debate needed to coalesce a national-level unity of effort. Of course, the classified nature of space weapon programs and emerging threats make it difficult to cultivate any sort of widespread political will or domestic consensus.

Fiscal Impediments. Although improved technology has made space more accessible, it is still incredibly expensive, and fierce competition with other spending priorities will define the fiscal outer limits of space weapons. The Congressional Budget Office projects budget deficits totaling $1.9 trillion over the coming decade.[132] Political pressure to reduce deficits has historically yielded cuts to DoD's budget. These facts paint a grim picture for significant additional federal funding targeted at space. Therefore, space must contend for limited resources against other weapons programs for the foreseeable future—tradeoffs within current programs is an unpopular and contentious venture with a dubious prospect for success.[133]

Options Compared.

1. Repudiation: Lead the way with a total repudiation of all offensive space weapons. The U.S. can repudiate deployment (but not necessarily development) of all offensive space weapons. Defensive weapons with inherent but unavoidable offensive capability must also be addressed. *Advantages:* (1) Strengthens our international diplomatic role and lends credibility to a "lead by example" diplomatic effort; (2) preserves the viability of an international treaty; and (3) no

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Governing the Activities of States on the Moon and Other Celestial Bodies available at http://www.oosa.unvienna.org/SpaceLaw/treaties.html)

[130] Singer, Jeremy, *USAF Aims to Neutralize Anti-Satellite Weapons*, Defense News, February 2, 2004, at p. 19; Hitchens, Theresa, *Reining in Our Weaponry: Is U.S. Air Force Lost in Space?*, The San Francisco Chronicle, March 16, 2004 (http://www.commondreams.org/cgi-bin/print.cgi?file=/views04/0315-05.htm)

[131] *See generally* Krepon, Michael, *Dominators Rule*, Bulletin of Atomic Scientist, January/February 2003; McKnight, John C., *Let's Weaponize Space*, Space Daily, January 30, 2003 (www.spacedaily.com/news/oped-03d.html).

[132] Kosiak, Steven, FY 2005 Defense Budget Request_DoD Stays the Course on Spending Plans, January 30, 2004. (http://www.csbaonline.org/4Publications/Archive/U.20040130.FY_2005_Defense_Bu/U.20040130.FY_2005_Defense_Bu.htm)

[133] *See* Transforming America's Military, Hans Binnendijk, editor, *Controlling Space* by Stephen P. Randolph, National Defense University Press 2002, at p. 310-311. The author notes that maturation of technology allows UAVs to move into mission areas previously reserved for space assets. This sort of encroachment typifies one aspect of how fierce competition for resources could unfold.

impact on the federal budget (i.e., the cost of diplomacy is small when compared to the cost of an offensive space weapon). *Disadvantages:* (1) Effectiveness of repudiation requires a sweeping international agreement (but how can the U.S. sign a treaty with non-state, transnational actors?); (2) vulnerability of existing space systems is unchanged; (3) technological edge will shrink over time; (4) eventually another nation will be the first to deploy an offensive space system; and (5) our national political will is divided—there is simply no widespread support for this option at this time.

2. Weaponize: Develop and deploy offensive space weapons. Seize the initiative, exploit currently available technology, and pioneer deployment of the first offensive space system. *Advantages*: (1) Gains a strategic advantage by being first to deploy space-based weapons; (2) recognizes inevitability of weaponization (our self-restraint "is no guarantee that potentially hostile nations (such as China) will not develop and deploy their own ASATs"[134]); (3) maximizes protection of space assets; (4) potential to replace nuclear weapons as the primary deterrent to aggression;[135] (5) bolsters the commercial and civil space sectors by guaranteeing a safe, secure environment for economic development;[136] (6) fosters new security alliances/agreements with friends/allies seeking mutual security for their own space assets; (7) acknowledges that space is just another medium like land, sea, and air. *Disadvantages:* (1) Cost prohibitive under the present federal budget; (2) may precipitate a costly arms race and proliferation of space/ASAT weapons[137] and foster a similar cosmic peer competitor to emerge;[138] (3) undermines U.S. foreign policy and provokes a diplomatic breakdown that could further isolate the U.S.;[139] (4) political will is divided; and (5) arguably little tactical advantage *and* a high potential for adversary's asymmetric defense (e.g., an expensive weapon neutralized by a cheap defense).[140]

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[134] Pena, Charles V., *Should the U.S. Weaponize Space?*, USA Today National Affairs, July 2002, at p. 17.
[135] This is analogous to "Cold War" thinking—by dominant military might, peer competitors were deterred from aggression. (Those that argue space weapons will cause destabilization miss the point. As with nuclear weapons or weapons of mass destruction, what matters is who has them—"a Saddam Hussein or Tony Blair," and "in what security context." *See* Lambakis, Steven, *Space Weapons: Refuting the Critics*, Policy Review, February/March 2001, at p. 46.
[136] Analagous to the way that a strong navel presence protected commercial trade ships from piracy. *See* Lambakis, *Space Weapons: Refuting the Critics*, at pp. 42-43.
[137] Pena, *Should the U.S. Weaponize Space?*, at p. 17. Again, the "Cold War" exemplifies how this might unfold. The U.S. and the Soviet Union squared off for decades through a massive build up of offensive weapons on constant alert (e.g., mutually assured destruction).
[138] Krepon, *Space Assurance or Space Dominance? The Case Against Weaponizing Space*, p. 126.
[139] Lambakis, *Space Weapons: Refuting the Critics*, at p. 42; *see also* Transforming America's Military, Hans Binnendijk, editor, *Controlling Space* by Stephen P. Randolph, National Defense University Press 2002, at p. 326.
[140] For example, low earth orbit weapons are easily tracked and vulnerable to ground-based attack by currently available ASAT technology.

3. Status quo: Develop offensive space weapon technologies, but refrain from deployment. The current direction of space weaponization appears to be development of technology, but no deployment of purely offensive weapons. This also includes deployment of defensive weapons that could be used offensively (e.g., missile defense system). *Advantages:* (1) Achievable considering current and projected budget constraints; (2) achieves most of the advantages of *repudiation* while avoiding most of the disadvantages of weaponizing space; (3) preserves our technological edge; and (4) most likely to appease the sometimes sharply divided political will. *Disadvantages:* (1) It is impractical, if not impossible, to deploy *only* defensive space weapons—the distinction between defensive and offensive employment is blurred by technology and capabilities; and (2) self-restraint is the only barrier to offensive employment of a defensive weapon (doubtful that self-restraint alone will deter a space weapons race).

Conclusion and Recommendation. Weaponization of space is inevitable. The U.S. should seize the initiative, preserve our technological edge, and secure the space environment for military and commercial exploitation. Over time, this bold action will foster global development and security.

The legal outer limits restrict, but do not prohibit, development and deployment of a national space weapon system. When Bush withdrew from the Anti-Ballistic Missile (ABM) Treaty[141] in 2002, he removed the single greatest legal impediment to an operational missile defense and space weapons program. The remaining limits are in the 1967 Outer Space Treaty: States shall not "place in orbit" *nuclear weapons* or *weapons of mass destruction*.

The outer limits of space weaponization imposed by political and fiscal impediments are enormous by comparison, but not indomitable. As national political and military leaders continue to publicly advocate the need for space weapons, the eventual national debate will foment a discernable national will, thereby providing the impetus needed for funding. The disadvantages of weaponization are real, but they should not deter us from making difficult choices about national priorities. As nuclear non-proliferation policy demonstrates, this nation can lead the world in prosperity and security while using diplomacy to curtail a space weapons race.

—Col Paul M. Barzler, USAF

[141] The 1972 Antiballistic Missile (ABM) Treaty limited the number of land-based anti-ballistic missile sites the USSR and the US could build. It also prohibited testing of sea-based or space-based ABM systems. Note that China was not a party to the treaty.